CORRELATION STUDIES: TEMPERATURE IN EASTERN UNITED STATES

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Two years ago I published a little study "Correlation Between Argentina Pressure and Temperature in the United States Six Months Later." (Monthly Weather Review, July, 1926, **54**:299).

In course of my further studies on this subject, I found also that Cairo spring pressure III–V (March–May) exerted a large influence upon the autumn temperatures in the eastern United States.

In order to study autumn temperature forecasts in the East, I have selected three territories, namely:

I. Northern area, represented by St. Louis, Cincinnati, and St. Paul.

II. The eastern coast, represented by Charleston, S. C., and Washington, D. C.

III. The Southeast, represented by Mobile, Charleston, and Key West.

I. THE NORTHERN AREA

(See table)

I have used the autumn temperature departures from the mean of the 50-year period, 1873–1922, by combining the departures for the above-mentioned cities. The autumn temperatures east of the Mississippi Valley depend principally on the preceding Cairo spring pressure and Argentina-May pressure. Following the methods of correlation, we obtain the following coefficients:

Correlation coefficients × 100

	North Δt IX–XI	Cairo Δp III–V	Argentina Δp V
North Δt IX–XI	100	49	−30
Cairo Δp III–V	49	100	−18
Argentina Δp V	−30	−18	100

From these we get the equations:

$$49 = 100a - 18c$$

$$-30 = -18a + 100c$$

Solving for a and c results in the following values: $a = 0.45$; $c = -0.22$.

The regression equation:

$$\frac{\Delta t \text{ IX–XI North}}{\delta_n} = \frac{0.45 \ \Delta p \text{ III–V } C.}{\delta_c} - \frac{0.22 \ \Delta p \text{ V Arg.}}{\delta_a}$$

If we substitute the numerical data for the δ in our formula the regression equation finally becomes:

$$\text{(I) } \Delta t \text{ IX–XI North} = 1.53 \ \Delta p \text{ III–V Cairo} - 0.32 \ \Delta p \text{ V Argentina}$$

where δ_n, δ_c, and δ_a signify, respectively, the standard deviations of the North, Cairo, and Argentina; Δ departures from the mean; t the temperature in °F.; p pressures in mm. Hg; and I, II, III–XI, XII the months, for instance III–V represents March–May.

If we now examine the table of departures we find the following interesting facts of large theoretical and practical importance.

1. In all cases in which the computed autumn temperature departures (from Forumla I) were $\geqq \pm 2°$ F., the observed departures also had the same sign (6 cases = 12 per cent); in the years in which the computations gave only $\geqq \pm 1°$ F. as departure, the observed departures had the same sign in 18 of the 21 cases, or 86 per. cent of the time.

2. In all cases where the Cairo spring pressure was $\geqq \pm 0.9$ mm. Hg. (8 cases = 16 per cent), the following autumn in the North had departures with like signs.

3. When Argentina pressure in May was especially low or high ($\geqq \pm 2$ mm. Hg.), the following autumn in the North was warm or cool, respectively, in all of the nine cases.

Therefore Argentina May pressure is inversely related to the autumn temperatures six months later in the United States.

The total correlation between Cairo pressure, March-May, and Argentina May pressure with the following autumn temperatures in the northern area is: $R^2 = (0.49 \times 0.45) + (0.30 \times 0.22)$; $R^2 = 0.2865$; therefore R total $= 0.53$.

II. EASTERN AREA (WASHINGTON-CHARLESTON)

The influencing elements on autumn temperatures are essentially the same as in the North–Cairo spring pressure and Argentina May pressure, but the influence of the first is less and of the second greater than for the North.

From these we get the equations:

Correlation coefficients × 100

	East Δt IX–XI	Cairo Δp III–V	Argentina ΔpV
East Δt IX–XI	100	33	−44
Cairo Δp III–V	33	100	−18
Argentina ΔpV	−44	−18	100

From these we get the equations:

$$33 = 100a - 18c$$

$$-44 = -18a + 100c$$

Solving for a and c results in the following values: $a = 0.26$; $c = -0.39$.

The regression equation:

$$\text{(II) } \Delta t \text{ IX–XI East} = 0.71 \Delta p \text{ III–V Cairo} - 0.46 \Delta p\text{V Argentina}$$

The total correlation between Cairo spring pressure and Argentina May pressure with the autumn temperatures for the East (Charleston and Washington) becomes: $R^2 = (0.26 \times 0.33) + (0.39 \times 0.44) = 0.2574$; therefore R total $= 0.51$.

If we examine the table of departures we find the following interesting facts, important for practical use:

1. There are 16 cases in which the computed (Formula II) autumn temperature departures were $\geqq \pm 1°$ F. Among this number are 14, or 87.5 per cent, in which the observed autumn temperatures had the same sign of departure.

2. Of these 16 cases there are 9 for which computation gave $\geqq +1°$ F., and in all of these the autumn was mild.

3. For 1917 the computations gave the largest negative value, and an excessively cold autumn followed, in fact the coldest in the southeastern part of the United States of the whole 50-year period.

III. THE SOUTHERN AREA (MOBILE, CHARLESTON, AND KEY WEST)

In general, the conditions for autumn temperature forecasts are the same as for the East and North, with the difference that Cairo spring pressure is of less influence. We obtain the following coefficients:

Correlation coefficients × 100

	Δt IX–XI South	Δp III Cairo	Δp V Argentina
Δt IX–XI South	100	29	−42
Δp III–V Cairo	29	100	−18
Δp V Argentina	−42	−18	100

From these we obtain the following equations:

$$29 = 100a - 18c$$
$$-42 = -18a + 100c$$

and the values for a and c as follows: $a = 0.22$; $c = -0.38$. The regression equation for this area is:

(III) Δt IX–XI South $= 0.45\ \Delta p$ III–V Cairo $- 0.33\ \Delta p$ V Argentina

The total correlation between the influencing elements and autumn temperatures in the South is computed as follows: $R^2 = (0.22 \times 0.29) + (0.38 \times 0.42) = 0.2234$; therefore R total $= 0.47$.

In examining the table we find that in all cases in which the computed temperature departures were $\geqq \pm 1°$ F., the observed departures had the same sign. In 1917 the computed autumn temperature departure gave the largest negative value of the whole 50-year period and the autumn was the coldest of the entire series.

Furthermore, we find two years later (in 1919) that the computations gave the largest positive departure, and the autumn in that year was the mildest.

This accordance in all the areas between computations and observations is the best argument for the correctness, usefulness, and importance of my formulas, and leaves no doubt of their practical value.

Departures from the mean

(50 years, 1873–1922)

Year	Autumn temperatures (°F.) eastern United States (Δt IX–XI)						Δp III–V Cairo	Δp V Argentina
	South		East		North			
	Obs.	Comp.	Obs.	Comp.	Obs.	Comp.		
							Mm. Hg.	*Mm. Hg.*
1873	−2.2	−0.1	−2.3	−0.3	−4.6	−1.1	−0.9	−0.8
1874	−0.5	−0.3	−0.2	−0.4	−0.2	0.5	0.7	1.9
1875	−0.8	−0.2	−2.6	−0.4	−3.9	−1.2	−0.9	−0.6
1876	−1.9	−0.2	−2.6	−0.3	−3.2	−1.1	−0.8	−0.5
1877	0.2	−0.4	0.8	−0.5	0.4	−1.2	−0.8	0.1
1878	−0.4	−0.2	0.2	−0.2	0.4	−0.2	0.0	0.5
1879	0.2	−0.2	0.5	−0.3	1.5	−0.3	−0.1	0.6
1880	−0.6	0.0	−1.9	−0.1	−4.0	−0.2	−0.2	−0.2
1881	2.5	0.7	4.8	1.0	2.3	1.1	0.4	−1.5
1882	−0.1	0.5	0.5	0.7	1.7	0.8	0.3	−1.1
1883	1.0	0.0	−1.0	0.1	−0.5	0.2	0.1	0.0
1884	0.7	0.2	2.0	−0.7	2.9	−0.8	−0.3	1.0
1885	−1.1	0.0	−0.8	0.0	−1.7	−0.4	−0.4	−0.7
1886	−0.3	−0.1	0.5	−0.2	0.0	−0.3	−0.2	0.1
1887	−0.7	−0.7	−1.4	−0.9	−2.1	−0.4	0.2	2.3
1888	−0.9	0.4	−1.9	0.6	−2.2	0.1	−0.3	−1.7
1889	−1.1	0.0	−1.5	−0.1	−3.4	−0.4	−0.3	−0.3
1890	0.2	−0.9	0.7	−1.4	−0.8	−2.2	−1.2	1.2
1891	−2.1	−0.1	−1.6	−0.2	−1.0	−0.5	−0.4	−0.3
1892	−1.2	−1.3	−1.8	−1.9	−1.2	−2.1	−0.8	2.8
1893	−0.1	0.0	−0.7	0.0	−0.4	0.4	0.4	0.6
1894	−0.4	−0.2	0.5	−0.3	−0.6	−0.6	−0.4	0.1
1895	−0.2	−0.7	−0.1	−1.0	−1.1	−1.2	−0.5	1.4
1896	1.1	−0.8	0.8	−1.1	−2.9	−1.2	−0.4	1.8
1897	0.8	0.1	0.8	0.5	3.5	0.7	0.3	−0.6
1898	−0.7	0.0	0.3	0.0	−0.6	−0.4	−0.4	−0.7
1899	0.7	0.7	0.4	1.0	3.0	1.0	0.3	−1.8
1900	1.6	0.1	3.2	0.2	3.4	0.3	0.2	−0.1
1901	−2.0	0.5	−2.3	0.8	−0.1	1.0	0.4	−1.1
1902	1.2	0.8	1.5	1.1	1.7	0.7	0.0	−2.3
1903	−1.6	−0.1	−2.0	−0.2	−1.2	0.5	0.6	1.3
1904	−0.3	−0.4	−1.5	−0.5	1.0	−0.5	−0.2	0.8
1905	1.2	0.1	0.0	0.2	0.1	0.3	0.2	−0.1
1906	0.7	1.0	1.2	1.5	0.6	1.7	0.7	−2.1
1907	0.3	−0.6	−1.0	−0.8	−1.5	−0.7	−0.1	1.6
1908	−0.4	−0.2	−0.3	−0.2	2.4	0.4	0.5	1.2
1909	0.3	−0.9	−0.6	−1.3	1.0	−1.6	−0.7	1.7
1910	−0.2	−0.5	0.2	−0.6	−0.1	0.0	0.4	2.0
1911	2.0	0.1	0.6	0.2	−2.2	0.2	0.1	−0.2
1912	0.3	0.7	1.0	1.2	1.6	2.4	1.5	−0.2
1913	−1.0	0.2	−0.3	0.3	1.3	0.3	0.1	−0.5
1914	−0.6	0.6	−0.5	0.9	2.3	1.7	1.0	−0.5
1915	2.2	1.0	2.2	1.4	2.3	1.0	0.0	−3.1
1916	−0.1	−0.6	−0.5	−1.0	−0.1	−2.3	−1.6	−0.4
1917	−2.6	−1.3	−4.0	−1.8	−2.7	−1.3	−0.1	3.7
1918	0.2	−0.2	−0.5	−0.4	−0.7	−0.8	−0.5	0.0
1919	3.6	1.5	3.5	2.1	0.7	2.5	1.0	−3.1
1920	−0.1	0.9	0.7	1.3	2.3	1.4	0.5	−2.1
1921	2.1	0.5	2.6	0.7	1.3	0.1	−0.3	−1.9
1922	1.2	0.7	1.5	1.0	3.7	2.0	1.2	−0.4
δ =	1.26	0.59	1.67	0.86	2.08	1.11	0.61	1.43

HEAVY SNOWFALL OF JANUARY, 1929, AT DUBUQUE, IOWA

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A new record has been set for all months by the heavy snowfall of January. The total fall of 34.3 inches is without precedent in the history of the station. The only previous monthly fall which approached this record was 32 inches in December, 1887. The heaviest single fall in 24 hours was 11 inches on the 4th and 5th. This is the largest single snowfall in the last 17 years. The accumulated average depth at the close of the month amounted to 20.1 inches, and this appears to have exceeded all previous records for the last 36 years, excepting one similar record of 20.5 inches in January, 1910. The snows of the last month have brought the winter's fall to date to 39.7 inches, which is more than a normal entire winter's fall. Practically the entire month's precipitation was from snow, amounting to 3.13 inches, which is the largest for January in 42 years.

The snows of the month were of unusual significance in the character of ground cover which resulted with its devastating effects upon street and highway transportation as well as damage to roofs and other property. Perhaps no snows have every developed greater persistency in accumulating and hardening upon pavements, rendering the operation of vehicles difficult and dangerous at all times after the first heavy fall, on the 4th and 5th. The conditions were decidedly aggravated along street-car lines where the rails became deep channels or ruts in the heavy masses of frozen snow which covered the streets from 6 to 12 inches thick generally and as much as 18 inches thick in places. These conditions steadily grew worse, and the city finally resorted to the use of snowplows, tractors, scarifiers, graders, picks, and trucks from the middle of the month on into February in an effort to